DEVELOPMENTS OF PC BASED CONTROLLER FOR BUCK CONVERTER DRIVEN DC MOTOR

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SUPERVISOR'S DECLARATION

I hereby declare that I have read this project report and in my opinion this project report is sufficient in terms of scope and quality for the award of Bachelor in Electrical Engineering (Power System)

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STUDENT'S DECLARATION

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

Switched Mode Power Supplies (SMPS) is the technique proposed in this investigation to control the speed of DC motor. In the design of these power supplies, the semiconductor devices are either switched on or off. It is highly efficient because of the low voltage drop across the semiconductor device when it is on and cause the power consumption is low. The power supply is consists of rectifier and Buck converter. The implementation the PWM Chopper with a MOSFET also needed because nowadays, the chopper switch is obviously a fast power MOSFET with very short switching times and low resistance that reduce the conductive losses but produce extremely high voltage- and current-rates. As the result, PWM signal is used to control the speed of the motor and the output voltage of the buck converter with the adding of PC interface in order to make it easy and friendly user system.

ABSTRAK

Switched Mode Power Supply (SMPS) adalah teknik yang dicadangkan dalam penyiasatan untuk menyiapkan projek ini iaitu untuk mengawal kelajuan motor arus terus (DC). Dalam mereka pembekal kuasa ini, semikonduktor samada suisnya buka atau tutup, ia mempunyai kecekapan yang tinggi kerana kadar kejatuhan voltage adalah rendah apabila melalui semikonduktor dan mengakibatkan penggunaan kuasa juga adalah rendah. Pembekal kuasa ini adalah terdiri daripada rectifier dan buck converter. Penghasilan PWM Chopper dengan MOSFET juga sangat diperlukan sekarang kerana suis chopper adalah terbukti sebagai MOSFET yang mempunyai masa suis yg sangat rendah dan rintangan yang rendah yang dapat mengurangkan kehilangan konduktor tetapi menghasilkan kadar voltan dan elektrik yang tinggi. Kesimpulannya, Pulse Width Modulation (PWM) digunakan untuk mengawal kelajuan motor dan kadar keluran voltan daripada buck converter dengan penambahan sistem interface komputer dalam menghasilkan sistem yang mudah dan selesa bagi pengguna.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter will explain the objectives of the project, scope of the project, problem statement and the project background. The review of the DC motor, chopper drive, buck converter and pulse width modulation (PWM) control also will be explained in this chapter. At the end of chapter 1 the thesis outline is briefly described.

1.2 Background

The DC motor is an attractive piece of equipment in many industrial applications requiring variable speed and load characteristics due to its ease of controllability. The “Chopper drive” based speed controlling method is superior in comparison to “Thyristor Controlled Bridge Rectifier” method as far as DC motor speed controlling is concerned. PC based software controlling is adopted to retain simplicity & ease of implementation.

By using PC and a circuit driver in controlling speed of a DC motor, the speed of a DC motor can easily handle and measure by the user. From this project also will shows the required signal generation to drive the chopper.

A Closed-loop designing a complete automatic speed control system for a DC motor and will brings the motor to the speed set by the user irrespective of the load.

1.3 Objective Of The Project

The project has these following objectives:

- To evolve of a PWM Signal Generator for chopper drive
- To design and apply chopper circuit in controlling DC motor
- To develop software implementation for interface

1.4 Scope Of The Project

This project is developed by using input from PWM signal generation to get PWM output. The implementation the PWM Chopper with a MOSFET also needed because nowadays, the chopper switch is obviously a fast power MOSFET with very short switching times and low resistance that reduce the conductive losses but produce extremely high voltage- and current-rates [2]. Program code also will be created to drive the hardware circuitry by using MATLAB and the implementation of PIC controller will be used for this project.

1.5 Problem Statement

Due to its ease of controllability, the DC motor is an attractive piece in requiring variable speed and load characteristics. Hence, the ‘Chopper drive” based speed controlling method detected as superior in comparison to “Thyristor Controlled Bridge Rectifier” method. It is also adopted to retain simplicity and ease of implementation. PC interfacing also will be giving the easier way to the user on how to control the motor speed.

1.6 Project Background

The overview of chopper drive and buck-converter will take part for this section besides the methodology in developing this project. In addition, the methodology will be best described in the block diagram as in Figure 1.

1.6.1 Overview Of Chopper Drive And Buck-Converter

The chopper is used to control the armature voltage of a DC motor [1]. Chopper drive circuits are also referred to as constant current drives because they generate a somewhat constant current in each winding rather than applying a constant voltage. A Buck converter consists of the power stage and feedback control circuit. The power stage includes power switch and output filter. It converts a higher input voltage to a lower output voltage. The feedback control circuit regulates the output voltage by modulating the power switch duty cycle. The three basic this dc-dc converters use a pair of switches, usually one controlled (MOSFET) and one uncontrolled (diode) in order to achieve unidirectional power flow from input to output.

1.6.2 Methodology of the Project

In the research of this project, motor will receives the input from the DC source. Signal also will be send to the motor through the chopper after PWM generator gives the output to the chopper that is result from the feedback speed. Feedback speed that comes from the sensor attached to motor will be the input to the PWM generator and PIC controller. This project will be applying the closed-loop system. A closed-loop designing a complete automatic speed control system for a DC motor and will brings the motor to the speed set by the user irrespective of the load.

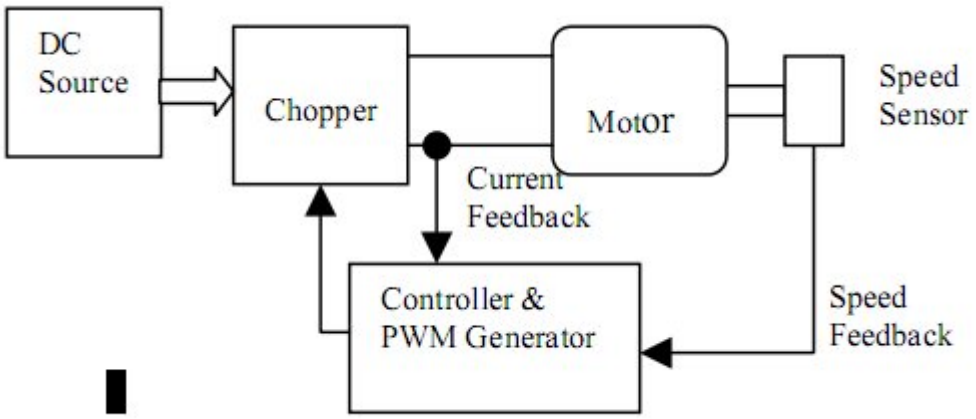

Figure 1: The block diagram of the project

1.7 Thesis Outline

This thesis is divided into 6 chapters which the content of each chapter is summarized as below.

Chapter 1 will be discussed about the overview of the concept of the project, objective of the project and scope of the project.

Chapter 2 will be described briefly the hardware components used in this project, including their description of operation and article review of the project.

Chapter 3 will be focused on the methodology of this research project which includes the generation of power supply, generation of PWM waveform for the motor and full circuit diagram of the project.

Chapter 4 will elaborated in detailed about the designing step of buck converter and chopper drive, PMW generation and the PIC controller design.

Chapter 5 will focused on the result obtained from the simulation design using MATLAB and PROTUSE, the result obtained from hardware design and PC interface.

Chapter 6 will described the conclusion from the result and observation, the future recommendation and costing besides the commercialization of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter will explain in detail the operation of buck converter and chopper drive. Besides that, DC motor and pulse width modulation also will be part of the explanation in this chapter. In addition, all the circuit diagram and element that are related in order to develop this project also will be reviewed in detail.

2.2 Dc Motor

DC motor is a mechanical workhorse. Many large pieces equipment depend on a DC motor for power to move. A DC motor rotates as a result of two magnetic fields interacting with one another. There are three categories for the DC motor like series DC motor, shunt DC motor and compound DC motor.

The speed control is concerned not only with starting the motor but also with maintaining or controlling the motor speed while it is running. There are a number of conditions to be considered for speed control for example constant speed, varying speed, adjustable speed and multispeed[3].

Table 2.1 : DC Motor Characteristics and Applications [7]

Speed Regulation	Speed Control	Starting Torque	Pull-out Torque	Application
Series DC Motor				
Varies inversely as the load. Races on light loads and full voltages in	Zero to maximum, depending on control and load.	High. Varies as square of voltage. Limited by the communication, heating, and line capacity.	High. Limited by communication, heating, and line capacity.	Where high torque is required and speed can be regulated.
Shunt DC Motor				
Drops 3% to 5% from no load to full load.	Any desired range, depending on motor design and type of system	Good with constant field, varies directly as voltage applied to the armature	High. Limited by communication, heating, and line capacity	Where constant speed is needed and starting conditions are not severe
Compound DC Motor				
Drops 3% to 2% from no load to full load depending on the amount of compounding	Any desired range, depending on motor design and type of control	Higher than for shunt, depending on the amount of compounding	High. Limited by communication, heating, and line capacity	Where high starting torque combine with fairly constant speed is required.

For this project, stepper motor is chosen that its speed will be controlled by the computer. The stepper motor is designed to move in finite increments (steps) in either direction and to keep track of how many steps have been taken at any point in time. The stepper motor can be used with mechanical linkages to provide precise positioning. [2]

2.3 Chopper Drive

DC motor drives are used for many speed and position control systems where their excellent performance, ease of control and high efficiency are desirable characteristics. DC motor speed control can be achieved using switch mode DC to DC chopper circuits.

Chopper Driver is chosen for this project due to the advantages against the Thyristor. These are the following advantages over Thyristor Bridge Rectifiers method:

- High energy efficiency
- Flexibility in control
- Quick Response
- Light weight & compact control unit
- Less ripple in the armature current
- Small discontinuous conduction region in the Speed-Torque plane
- Small discontinuous conduction region improves the speed regulation and transient response of the drive
- Less amount of machine losses due to less ripple in the armature current
- Ability to control down to very low speeds [4]

For step-down converter operation the chopper circuit in figure can be used. The average voltage applied to the motor, and hence its speed, is controlled by varying the duty cycle of the switch, S.

Figure below shows the switching waveforms for the circuit. During the on time, ton, the supply voltage, Vdc is applied to the motor and the armature current starts to increase. Neglecting the on-state resistance of the switch and the armature winding resistance the voltage across the armature inductance is Vdc-Ea and so the rate of rise of armature current is given by:

$$\frac{dIa}{dt} = \frac{Vdc - Ea}{La}$$

When the switch turns off the energy stored in the armature inductance must be dissipated. The polarity of the voltage across La reverses, the diode D becomes forward biased and the armature current continues to flow.

Assuming that the motor speed remains constant and neglecting the forward voltage drop of the freewheeling diode the inductor voltage is equal to -Ea. The rate of fall of armature current is given by:

$$\frac{dIa}{dt} = -\frac{Ea}{La}$$

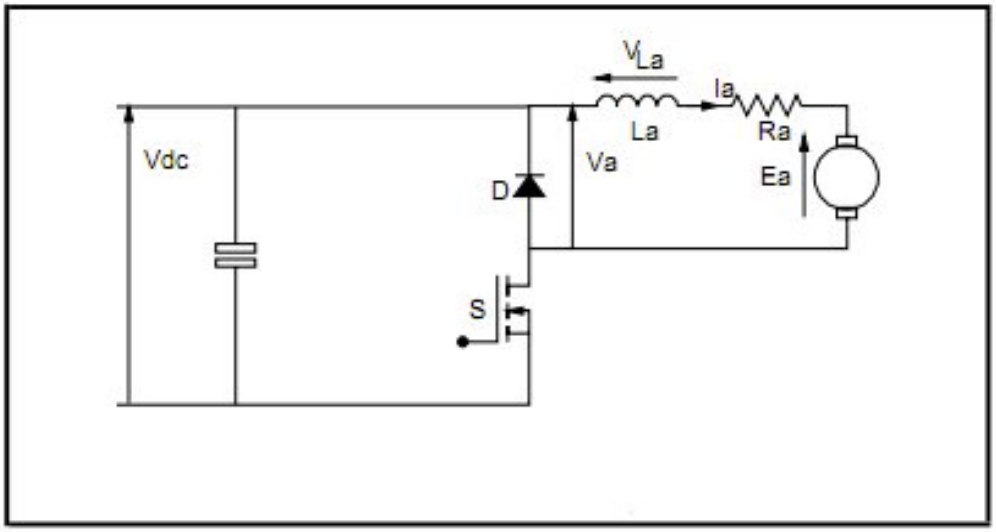

Figure 2.1: Step-Down Chopper Circuit

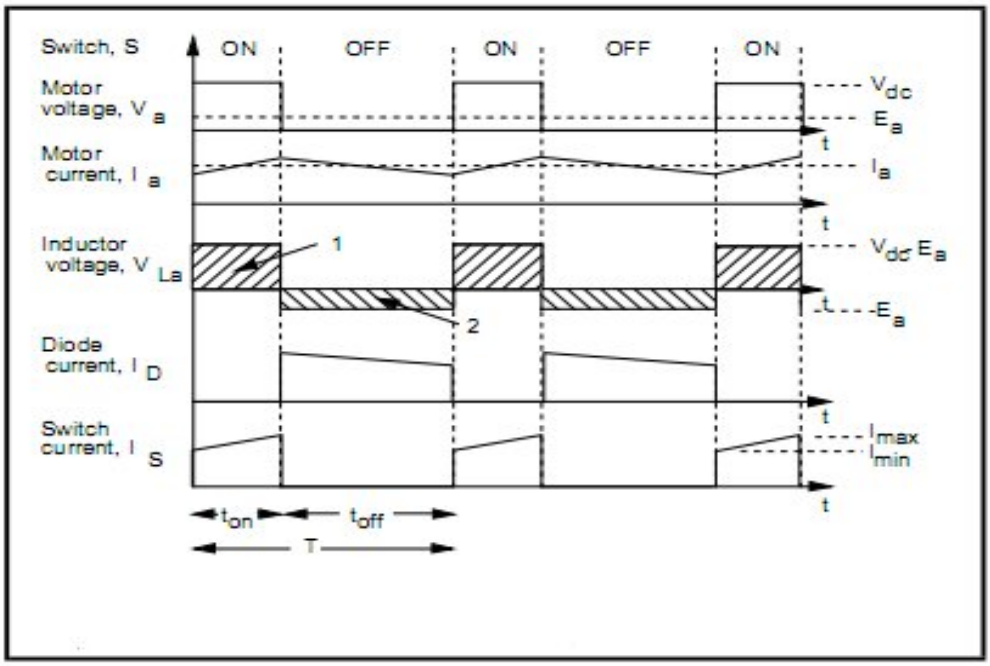

Figure 2.2: Step-down chopper switching waveform

If this switching sequence is repeated at some frequency, then the motor voltage can be controlled by altering the relative duration of the on period and off period. Variation of the duty cycle of the switch (ton/T) to control the motor voltage is referred to as Pulse Width Modulation (PWM) control. As the average voltage across the inductor over a period must be zero then:

$$\int_0^T V_L.dt = \int_0^{t_{on}} V_L.dt + \int_{t_{on}}^T V_L.dt = 0$$

The integral of inductor voltage for the interval t_{on} corresponds to the shaded area1 in figure, whilst the integral of inductor voltage for the t_{off} interval corresponds to the shaded area 2 in the Figure 2.2.

These two areas must be equal and so from equations and figure the transfer function of the controller is given by:

$$V_a = \frac{t_{on}}{T}.V_{dc}$$

2.4 Switched Mode Power Supply (SMPS)

For many years the world of power supply design has seen a gradual movement away from the use of linear power supplies to the more practical Switched Mode Power Supply (SMPS). The linear power supply contains a mains transformer and a dissipative series regulator. This means the supply has extremely large and heavy 50/60 Hz transformers, and also very poor power conversion efficiencies, both serious drawbacks. Typical efficiencies of 30% are standard for a linear. This compares with efficiencies of between 70 and 80%, currently available using SMPS designs.

Furthermore, by employing high switching frequencies, the sizes of the power transformer and associated filtering components in the SMPS are dramatically reduced in comparison to the linear. This means an SMPS design can produce very compact and lightweight supplies. This is now an essential requirement for the majority of electronic systems. The supply must slot into an ever shrinking space left for it by electronic system designers.

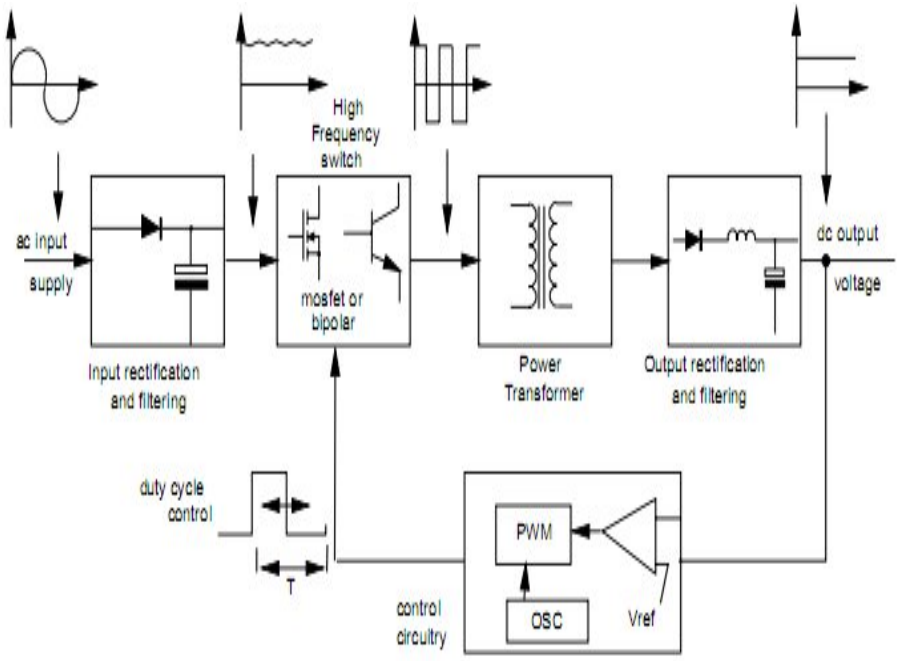

Figure 2.3: Basic SMPS block diagram

An SMPS can be a fairly complicated circuit, as can be seen from the block diagram shown in figure above. (This configuration assumes a 50/60Hz mains input supply is used.) The ac supply is first rectified, and then filtered by the input reservoir capacitor to produce a rough DC input supply. This level can fluctuate widely due to variations in the mains. In addition the capacitance on the input has to be fairly large to hold up the supply in case of a severe droop in the mains. The SMPS can also be configured to operate from many suitable dc input, in this case the supply is called a DC to DC converter. In a switching converter circuit, the transistor operates as an electronic switch by being completely on or completely off and this circuit is also known as a DC chopper [6].

2.4.1 DC – DC Converter

DC to DC converter is an electronic circuit which converts a source of direct current (DC) from one voltage level to another.

There are few converters that are listed in this DC to DC converter such as:

- Buck Converter
- Boost Converter
- Buck Boost Converter
- Cuk converter
- Full bridge converter

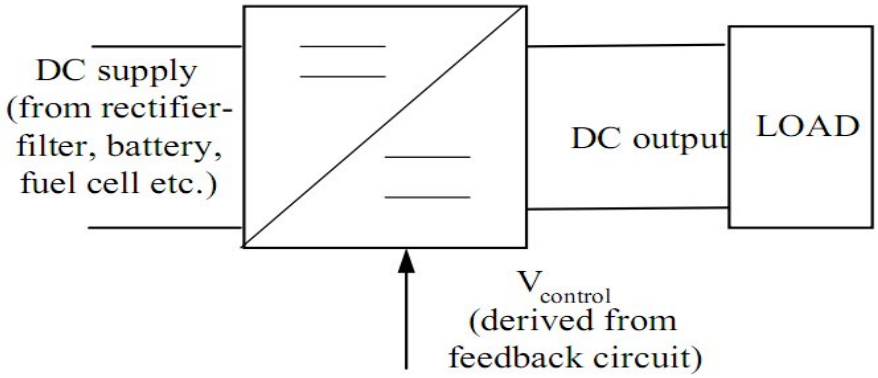

Figure 2.4: General Block Diagram for DC to DC converter

Switching power supplies offer higher efficiency than traditional linear power supplies. They can step-up, step-down, and invert. Some designs can isolate output voltage from the input. The switching regulator used in DC-DC converter and this may be a simple way of converting a DC supply voltage to a lower Dc voltage and regulating the output[6].

2.4.2 Buck Converter

A buck converter is a step-down DC to DC converter. Its design is similar to the step-up boost converter. It is a switched-mode power supply that uses two switches (a transistor and a diode), an inductor and a capacitor similarly like the Boost Converter. The diode provides a path for the inductor current when the switch is opened and is reverse biased when the switch is closed.